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LABORATORY MANUAL

FOR

GENERAL ZOOLOGY

ACHORDATES

BERT CUNNINGHAM

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ACHORDATES

BY

BERT CUNNINGHAM
Duke University

1932

REVISED

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PREFACE

This manual is designed to accompany a lecture course in general zoölogy, beginning with the simpler organisms and treating them in an ascending series to the chordates.

The animals which are presented illustrate the progressive development in the increasing complexity of the organism; and, although not following precisely the evolutionary sequences, furnishes a good background for evolution.

The exercises are prepared for a two-hour period, the amount of detail being regulated, to some extent, by the time factor as well as by the importance of the animal under examination.

Provision has been made for exigencies, which always occur when an effort is made to use as much live material in the laboratory as it is possible to use, by placing a few additional animals in the outline.

This additional supplementary work will also provide interest for the unusual student who may complete the usual routine in a short time.

In the preparation of this manual, the writer has had many helpful suggestions from Dr. A. S. Pearse who also contributed Exercises 12 and 14, as well as much helpful criticism from various members of the Staff. Exercise 8 was prepared by Miss Butts and Mr. Rice, and the part of Exercise 27 dealing with termites was prepared by Miss Butts. To all these the writer wishes to express his appreciation.

GENERAL INFORMATION

The expensive instruments such as microscopes, as well as charts, models and animal materials, are furnished by the Institution. The student, however, is expected to provide himself with the following equipment before coming to the first laboratory period:

Laboratory note book—Zoölogy.
Laboratory manual.
3 H drawing pencil (Do not use anything softer as it will smear).
Pencil eraser.

The following instruments:

- (a) Razor knife or scalpel.
- (b) Forceps, preferably two pairs, one fine pointed.
- (c) A pair of small, sharp-pointed scissors.
- (d) A paper of pins, medium size.
- (e) At least two needles, either in bone or wooden handles.
- (f) A small medicine dropper.

The student is expected to attend the laboratory section regularly and work for the full time. While the exercises are arranged with the average student in mind, the exceptional student will be given an opportunity to examine materials not given to the class in general. It may be necessary for a slow student to work overtime.

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INTRODUCTION

Laboratory work has as its chief function the introduction of the student to the method of securing first hand information for himself.

Note Book

In a course of this kind, the laboratory serves to present animals which illustrate certain zoölogical principles. The laboratory note book, therefore, becomes a valuable aid to the student when time for review comes. The more accurate, and the fuller the data recorded therein, the more of value the book will have. The laboratory note book should not be looked upon as "home work" which an eagle-eyed instructor is to correct, but rather as a personal note book containing a record of that which the student has actually observed. The work of the instructor is to aid the student to learn how to collect, organize, and illustrate data. The student should find and correct his own mistakes.

Making Observations

The student should find out everything he can about the materials under observation, regardless of whether specific questions are asked or not. Minute detail should be observed and recorded. A longer study of material often gives great returns for the effort.

Recording Observations

All observations should be neatly recorded, and, where possible, systematically arranged. In comparative studies, tables are often the most convenient method of recording. In making records as well as drawings, the student should remember that a neat, clean-cut piece of work is indicative of good scholarship.

Drawing

This course is not framed for the artist but for the average person. Drawings can be scientific, neat, show what the student sees, and yet not be the work of an artist. On the other hand, an artistic drawing may be very inferior from the standpoint of scientific accuracy. It is surprising to see how much easier it is to draw a structure that is observed under the microscope than it is to draw an object under other conditions.

The fundamentals of a good drawing are clean-cut lines, absence of shading in general, and proper labeling, which involves lettering and straight lines from the structure shown to the legend. But little more time and care are required to make a presentable book than an unsightly one. Students, who have the time and wish to do so, may trace the drawings with black India ink.

Drawings must be placed on the right hand page and should be large enough so that any detail shown is easily seen; however, they should not be so large as to appear cumbersome. The line leading from the structure to the symbol letter should, in so far as is possible, be parallel with the bottom of the page; and, in all cases, the symbol letter should be perpendicular and of a neat size.

A key to the meaning of the symbol letters should be placed on the left hand page facing the drawing. A sketch illustrating this will be placed on the board. All structures shown must be labeled.

When a student has completed a drawing, it should be submitted to the instructor for approval.

Care of Desk

Several persons may find it necessary to use the same desk and microscope; therefore the student should remove all paper, any remains of specimens, and any water from the desk. The microscope should be properly put away in good condition after each exercise.

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EXERCISE 1

Field Trip

With nets, spades, trowels, bottles and vials, go out into the fields. Take along your Manual and a pencil. Collect on land, in water, and underground. Keep the animals from each habitat segregated in appropriate containers. After collecting, sit down in a favorable place and discuss with your instructor the animals which you have collected and observed.

1. Enter the names of animals collected from each habitat in the table on the following page, and fill in appropriate facts in each of the columns.

2. With the help of your instructor, try to answer the following questions:

(a) What are the characteristics of aquatic, subterranean, and terrestrial animals?

(b) What are characteristic adaptations in each of the habitats studied?

(c) What are the advantages and the disadvantages of life in each of the habitats studied? Illustrate by the animals collected.

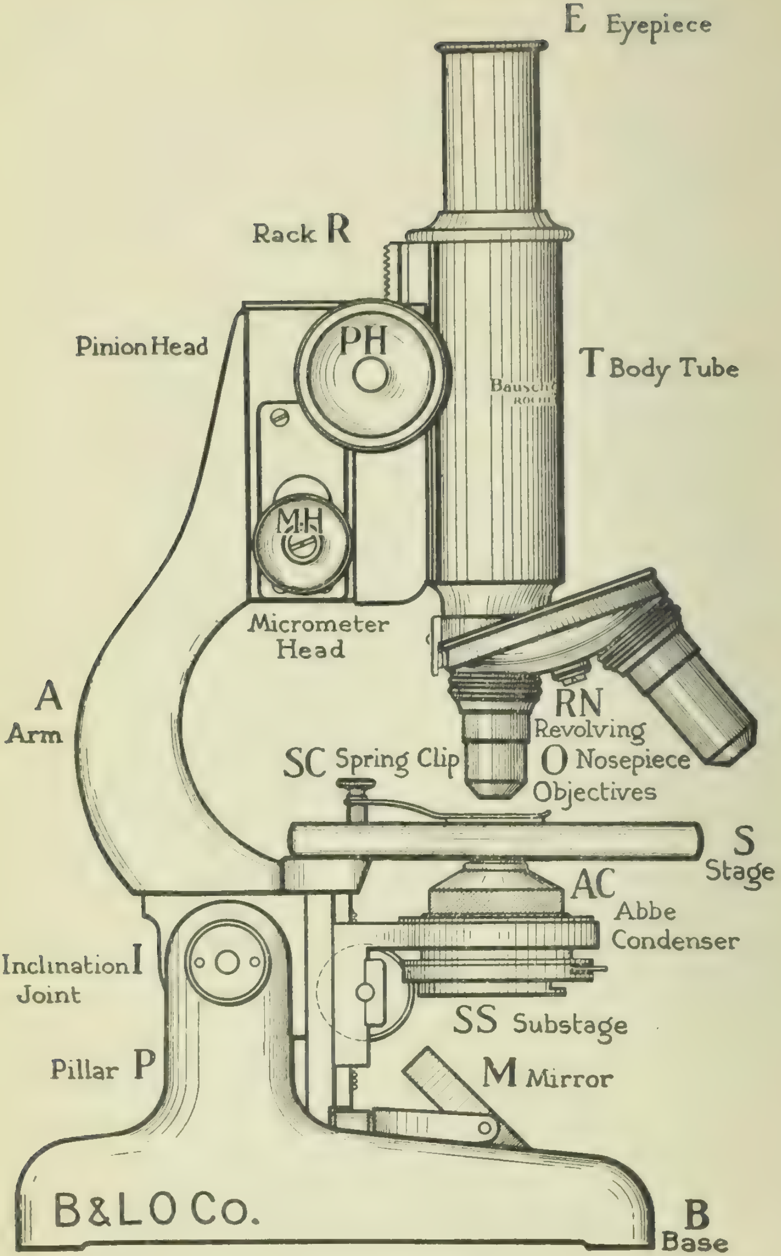
(d) Why are the immature stages of some insects found in water and the adult stages found on land (and vice versa)? Which is the primitive habitat for insects, land or water? For snails? For vertebrates?

(e) Are suitable animals selected by habitats or do animals seek out habitats that fit?

3. When the chart is completed it is to be removed and pasted into your laboratory note book, along with a discussion of the questions raised.

ECOLOGY OF AQUATIC, SUBTERRANEAN, AND TERRESTRIAL ANIMALS

Animal	Habitat	Body Form	Locomotion	Respiration	Food	Water conservation



A Microscope

EXERCISE 2

In any scientific study, it is always desirable to supplement or supplant the human senses by the use of instruments which cannot be influenced by what the observer may think. These instruments may be of various kinds, such as: balances, telescopes, recording devices, or microscopes. The latter instrument, because it magnifies objects so that their detail may be more readily seen, has proven of great value in biology for the study of the whole organism, as well as of its parts. Because of this, and because our observations in zoölogy will begin with structures and whole but minute animals which are invisible, or almost invisible, to the eye, a little time should be spent in studying the microscope.

A microscope is a valuable instrument and it should have good care. Any difficulty should be reported at once to the instructor. Care should be taken not to push the instrument too close to the edge of the table where it may be knocked off by those passing. Before using the microscope, read the list of "Don'ts."

The Microscope

From the figure, locate the various parts of your microscope and learn their names. When speaking of any part, always use the proper (technical) name. Determine the use of each part so far as you can. The mirror, used to reflect daylight through the tube from below, will not generally be used in this laboratory because of the sub-table lighting system. However, see if you can direct light with the mirror through the microscope.

Objects to be examined under the microscope should first be examined under the "low power." This is the short objective. In general, nothing should be examined under the high power (the long objective) without first being covered with a cover glass; this is especially true of materials in liquids.

Remove the mirror; place the microscope over the light window in the table and turn the light switch at the end of the table. Place your lower power lens in line with the barrel of your microscope and adjust it so that it is about ¼ inch from the stage. Look through and adjust until the field is equally illuminated.

Secure a drop of the hay infusion, cover with a cover glass, and place it on the stage of the microscope. While observing from the side, bring the lens down to within about ⅛ of an inch from the slide. Looking through the microscope, move the lens upward slowly. If nothing is seen before the lens reaches a distance of ¾ of an inch, try again. A beginning student should never focus down for any appreciable distance while looking through the microscope. When the materials are in focus, look over the slide for as many different kinds of moving objects as can be found. The instructor may be questioned as to the names of the various organisms

observed, but it is possible that he may not always be able to give the desired information. Fix your attention on some slowly moving object and then, by moving the slide, try to keep it in sight.

Among the objects on the slide may be seen green or brown, oblong, box- or boat-like structures, moving very slowly or apparently not at all. Get one of these directly in the center of the field by moving the slide, then focus up a little. Now put the high power lens into line with the barrel of the microscope and, observing from the side, bring the lens as near to the cover glass as possible without touching. Look through the microscope and focus up slowly. The object, a diatom, which is a plant cell, should come into view. The details can now be seen, especially the markings on the shell, which is made of silica. Practice with more rapidly moving objects until you can work efficiently.

Don'ts

1. Don't focus down for any distance while looking through the microscope. You may break a slide if you do.
2. Don't get water on the objectives. If you do, wipe the lens clean and dry with lens paper.
3. Don't place microscope too near the edge of the table.
4. Don't use anything but lens paper to clean the lenses. Do not remove lenses from microscope except to change oculars. If anything goes wrong, call the instructor.
5. Don't use too much light. The amount of light can be reduced by closing the diaphragm.

EXERCISE 3

Textbooks often speak of the ''typical'' cell and proceed to describe it; but, like many other typical things, the ''typical'' cell rarely exists. Numerous cells of various types would, of necessity, have to be studied, and features found in several varieties would have to be assembled in a single cell for it to be similar to the type described as typical. Several types of cells are to be studied which will illustrate this point as well as give a concept of a cell.

Cells

Using one of your clean slides, scrape lightly the inside of your cheek. Transfer a small part of the material collected to a clean slide, add a very small drop of water and cover with a clean cover slip. Examine under the microscope. Among other things may be seen small, irregular, flat, block-like objects. These are cells, most of which are dead. The limiting membrane is quite evident, and, in some cases, a spherical structure (nucleus) is evident at about the center.

* *Make a sketch showing any details of structure that you ob-*
* * *served.*

Now place a small drop of iodine at one side of the cover slip; with a small piece of blotting paper touched to the liquid at the opposite side of the cover slip, draw the iodine under the cover. Examine the cells. If the cell wall and nucleus were not easily seen before, they should now be quite distinct. The space between the nucleus and the cell wall, in a living cell, is filled with cytoplasm. See if you can find any other structures which are characteristic of ''typical'' cells.

* *Add any details observed in the stained cell to your previous*
* * *sketch.*

You have observed that staining brings out certain details of a cell which are invisible without it. Now examine some skin of a frog under the microscope. Note that it is made up of numerous cells which seem to fit into each other but which are not attached to each other by any visible means.

* *Draw several adjoining cells illustrating this relationship. If*
* * *nuclei or other details are observed, include them.*

Examine a slide of turtle or salamander testis. This is made by cutting slices from the organ; then mounting and staining them. Find cells which show much more detail, especially in the nucleus, than you observed in the preceding study under the high power lens. Find a cell in which a long, thread-like structure, stained blue or black, is wound around in the nucleus. Note all

the details that you can find. The long thread is called the linin; the knots of stained material are chromatin. A spherical structure may be observed outside, but near, the edge of the nucleus. This is the centrosome. The nuclear membrane separates the nucleus from the cytoplasm, both of which are composed of protoplasm.

* *Draw a single cell including all the details that you observed.*
* *

Students who have time will be permitted to examine plant cells.

EXERCISE 4

New cells are formed by the division of a cell into two or more cells. This may be a simple pinching off of a part of the cell or nucleus without special relation to the chromatin material (amitosis) such as happens in yeast or it may be quite an elaborate process such as you are to observe in this exercise. Remember that the cells you are studying were killed while dividing, and that the term “stage” is general rather than specific. Also remember that the cells are preserved and stained.

Cell Division

Using again a slide of a turtle or salamander testis, find and examine the “resting” cell. Note especially the chromatin knots and the thread (linin) on which they occur. Find, if possible, a deeply stained sphere (centrosphere) just outside the nuclear wall.

* *Make a drawing of a “resting” cell.*
* *

Find another cell in which the chromatin appears to be compacted into definite large masses (chromosomes), usually located in a flat plane across the equator of the cell. The nuclear membrane should not appear in this stage. If you are looking down on this from a pole of the cell, the chromatin material will look somewhat like black objects on a plate; if you are looking from the side, it will appear as a band across the middle of the plate. Both views should be found.

* *Sketch a view of this stage as seen from the pole, and also, as*
* * *seen from the side.*

Find a cell in which the chromosomes appear to be arranged in two more or less distinct rows. In a favorable specimen, very delicate fibers will appear to extend from each set and converge at a point some distance away in a small, darkly stained body (the centrosome). Some fibers continue beyond the centrosome producing a star-like appearance (the aster) with the centrosome at the center. Delicate fibers may be observed also between the two rows of chromosomes. You may not be able to determine this, but each chromosome has split lengthwise into two parts, one part of which is found in one row and the other part in the other row.

* *Sketch as viewed from the side.*
* *

Now find a cell which shows the chromosomes in two widely separated groups. Locate all the parts.

* *Sketch.*
* *

Find a cell in which the chromatin material is beginning to form again into a thread. The cell walls are probably dividing the mass into two cells and the nuclear membrane may, or may not be, reformed.

* *Sketch, including all the features suggested above.*

* *

The conditions observed above are a part of a continuous process in the living cell. Write a paragraph telling what happens in this (mitotic) type of cell division.

Note: Students who have time may, upon request, secure slides showing amitotic cell division. They may also examine slides of plant structures showing mitosis.

EXERCISE 5

Protozoa

All the cells which have been examined thus far are parts of a many-celled animal; they are, therefore, not as complicated as a single-celled organism. They were used because they are more readily observed by the beginner. A few of the single-celled animals are now to be examined. Each is in reality a cell which carries on all the life processes alone. Recalling that the life processes involve food getting, repair, growth, waste removal, reproduction, and response to stimuli, try to understand how each kind of organism carries out these processes.

The Amoeba

The Amoeba is a single-celled animal (Phylum-Protozoa) moving by a sort of flowing of the cell materials (Class—Sarcodina). The specimens to be studied are representatives of the species **Amoeba proteus.**

Use a clean slide. Secure a small drop of the culture and place it near the middle of the slide. Before placing the cover slip over the drop, a very small bit of glass should be placed at one side to prevent the weight of the cover from crushing the amoebae. Cut down the light so that you can barely see through under the low power. The amoeba will be most easily recognized by its movement, and will probably not be observed at the first glance. Find a specimen and watch its movements until you can describe them.

Note that there is a clear outer area, the ectosarc, which surrounds a more granular area, the endosarc. Within this granular material, find the nucleus. Notice how it is separated from the rest of the cell. Look for a clear space which contracts periodically (contractile vacuole). With what life processes would you think this to be connected? Within the endoplasm, pick out a single granule and follow it for a little while. What sort of path does it follow? With what life function would you think this streaming of protoplasm to be connected? If your specimen should attempt to "eat" something, watch the process, noting carefully everything that happens. What is a food vacuole? If the animal attempts to get rid of materials, such as sand or shells that are within the body, watch to see how this is done.

If you chance to see a specimen that looks as if it were dividing into two, call the instructor.

* *Make a sketch of an amoeba, including all you have observed.*

* *

Other Sarcodina

Many of the Sarcodina secrete shells. Some of these are made out of material (chitin) similar to those used in a crayfish or a

crab shell. These will often appear brown under the microscope. Find some of the animals that look like doughnuts. How do you account for this appearance? See if you can find the pseudopodia, and watch them move. These brown organisms probably belong to the genus Arcella.

⁂ *Sketch shell and pseudopodia, if they are observed.*

The internal anatomy of an animal can best be observed in one having a more transparent shell. If you find some, call the instructor who will help you to stain the material for examination.

Other Sarcodina have made shells of a glass-like substance; still others, of limestone; and some have cemented bits of sand which formed a protective covering. Find one of the latter. This is probably a Difflugia.

⁂ *Sketch shells and pseudopodia in so far as you have the time.*

EXERCISE 6

Protozoa (Continued)

Other protozoa, while still single cells, are much more complex in their structure than the Sarcodina. One of the two groups which have quite characteristic organelles for locomotion, is now to be studied.

Paramoecium

Paramoecium is a single-celled animal (Phylum-Protozoa) which moves by means of many vibrating threads called cilia (Class—Ciliata, or sometimes called Infusoria), that are equally distributed over the body (Order—Holotricha).

Secure a drop of water from the hay infusion and examine it for slipper-shaped animals. There are a number of animals which may be mistaken for Paramoecium by the beginner. However, in a good culture, the slipper shape is so characteristic that with care there should be but little error.

These animals will be moving about, and it will be necessary to move the slide continually if you wish to follow any single individual. Having found one, observe how it moves. Can you see any organs of locomotion? How does the outer part compare with that of the Amoeba? Do you think the body is cylindrical? See if the same end is anterior for the most part during locomotion. Does this suggest anything as to differentiation of protoplasm?

Find specimens feeding and note carefully the manner in which food is taken into the body. Can you see what happens to material which cannot be digested? Fix in your mind the line of movement of the food vacuoles in the body. How is a food vacuole formed? In what way does food distribution differ in Amoeba and Paramoecium? How do you suppose water that is taken in with the food vacuole is excreted?

Examine the demonstrations of animals which have been fed carmine.

Look for small, spherical cavities which seem to contract and expand periodically (contractile vacuoles). What do you think would be their function? Certain species have exceedingly large vacuoles with radiating canals. See if your specimen is of this kind. Note the number and the location of contractile vacuoles. These are often useful in determining the species to which an individual belongs.

Locate the nucleus. There are really two, a large one (macronucleus) and a small one (micronucleus). You may not find the latter until you have stained your material.

* *Draw a composite sketch, including, in so far as possible, all of*
* * *your observations.*

Add a little iodine at one side of the cover glass and draw it under with a blotter. Reëxamine, noting any changes and making such additions to your drawings as are necessary.

Secure a new drop of water from the hay infusion and place it on a clean slide as usual; then put a drop of alcohol at one side of the cover glass and draw it under with a blotter. Now study the structure of the cell wall.

Why is the cell wall spoken of sometimes as pellicle and sometimes as cuticula?

EXERCISE 7

Protozoa (Continued)

A. The second group of protozoans which have special structures for locomotion is now to be studied.

Euglena

Euglena is a single-celled organism, propelled by a long, whip-like structure, a flagellum (Class—Mastigophora) located at the anterior end. Green bodies are present in the cell; there is a rather flexible body wall and a red eye spot.

Secure a drop of culture and find a specimen. If the flagellate should be in motion, you will notice that it moves very slowly. Watch its method of locomotion. Is there any evidence of specialization of protoplasm in this organism? Notice a very small cavity (reservoir) which communicates with the outside through a small canal. Note the relation of this to the red "eye" spot and the flagellum. The green colored bodies present are chromatophores (or chloroplasts) similar to those found in plant cells. Are these organisms plants? Locate the nucleus, if possible. Stain with iodine, reëxamine, adding any new observations.

* *Make a sketch which includes everything that you have observed.*
* *

Reproduction. These organisms reproduce (1) by longitudinal fission in the free state, and (2) by fission during encystment. See if you can find any that are undergoing simple fission. Examine preserved material of encysted Euglena. Find cysts in which more than one individual may be seen.

* *Sketch specimens showing both methods of fission if you have*
* * *chanced to make such observation.*

Sporozoa

"All Sporozoa are parasitic and produce spores. As a rule they are incapable of movement, but some when immature move about by means of pseudopodia. They have no cilia or flagella" (Kudo). Sporozoa are for the most part internal parasites; some such as the malarial parasite live in the blood, some such as gregarines live in the intestine or the cavities of certain glands; and sometimes members of this group live within the cells of the host. Taken as a whole they are not satisfactory subjects for study by the elementary student.

Gregarine

This sporozoan lives in the intestine of the meal worm, and may be secured by cutting off the head and tail of the worm and pulling

out the intestine. This should be done as carefully as possible so as to avoid removing the fat bodies along with the intestine. The whole intestine should be placed on a slide in a drop of water, cut up into several pieces and covered. A gregarine is an ovoid organism, one end of which is slightly constricted and often semi-transparent. The posterior portion is much denser and contains the nucleus. For other details examine the chart or lantern slide.

⁂ *Draw a single individual.*

Malaria

Many diseases are due to Sporozoa, the most common in this region is probably malaria. Examine demonstrations of a malarial parasite, and consult the charts or lantern slides for details concerning life histories. Try to understand how malaria is transmitted.

EXERCISE 8*

Protozoa (Continued)

Intestinal Protozoa

The intestine of the termite, **Reticulitermes flavipes,** is invariably packed with protozoa. These protozoa belong to the Class Mastigophora and are commonly called flagellates. The relationship of at least some of these protozoa to their host is one of mutual benefit. It is believed that termites are able to utilize the wood which they eat, only when it is acted upon by certain of the protozoa living in their intestines. These protozoa digest a part of the wood (cellulose) which provides nourishment for both termite and protozoa. The termites, on their part, provide an environment suitable for the maintenance of the protozoa. A relationship such as this which exists between two different species of animals in which both are mutually benefited is termed symbiosis. Each animal is a symbiote.

Place a drop or two of 0.1 per cent solution of sodium chloride on a clean slide. Secure a living worker termite. Cut off the abdomen and macerate it in the drop of salt solution. Remove the remains of the abdomen and place a cover slip over the drop. Examine the slide immediately. Several different types of protozoa may be distinguished on the basis of their form and movement.

Pyrsonympha. The largest of the protozoa is somewhat the shape of an elongated pear with irregular edges which appear to be constantly in motion. This movement is caused by the wave-like vibration of the undulating membranes. The large nucleus may be seen near the anterior end. Look for the large irregular shaped bodies in the posterior part of the animal. These are probably particles of wood.

Examine a stained preparation of Pyrsonympha on a prepared slide. Observe the darkly stained central rod, or axostyle, which serves as a supporting structure.

* *Draw a Prysonympha from your observations of the living and*
* * *stained specimen.*

Trichonympha is the next largest of these protozoa. It is conspicuous by its long flagella, which are arranged in zones at the anterior end and extend laterally and posteriorly to form a more or less even cloak about the animal. Find the spherical nucleus which is central in position. Note the anterior nipple-like structure from which the flagella radiate when viewed from the anterior end. Look for particles of wood in the interior.

Examine a prepared slide for Trichonympha.

---

* This Exercise was prepared by Miss Butts and Mr. Rice.

* *Draw a Trichonympha from your observations and show all*
* * *structures observed.*

Dinenympha. Look for a protozoan which resembles a short piece of twisted ribbon. Watch its movement. It may be found in the extended or the contracted condition. Do you find particles of wood in it?

In the stained specimens on the prepared slide note the axostyle and anterior nucleus.

* *Draw two or three Dinenympha to show variation of shape*
* * *among animals of the same species.*

EXERCISE 9

Formation of Cell Colonies

The establishment of the principle of the division of labor, which becomes so important in the life of animals, is dependent upon cell colonization. A colony is a group of similar cells living together, even attached more or less loosely together, but in which each individual cell may carry on all the life processes more or less independently. The transition from individual to community life is well illustrated among the infusorians. A solitary species is first to be studied, followed by examination of colonial forms of the same type of animal.

Vorticella

Vorticella is a single-celled, bell-shaped animal having a contractile stalk by which it may attach itself to small bits of wood or other solid objects. The upper margin of the bell, that is, the large end, is surrounded with cilia which, in slow motion, appear as a rotating wheel.

Examine some of the hay infusion containing these animals. Note the shape, the location of the gullet and the mouth. Find the U-shaped nucleus.

If this is not evident in the living specimen stain lightly with Bouin's fixing fluid.

Examine the stalk and notice within it the contractile thread. This is much more evident when the stalk is contracted.

* *Sketch.*
* *

Examine the culture for dividing specimens and find one where there are two bells on a single stalk.

* *Sketch these bells in outline and show the contractile fibers in*
* * *detail.*

Carchesium

If available, examine living material. Note that each cell can and does contract independently of the others in a colony. If live material is not at hand, examine preserved material. See if the contractile fibers are continuous, that is, do they connect the various individuals through the stalk. Examine the cells for structures similar to those found in Vorticella. Can you suggest any way in which this type of animal might have arisen?

Zoothamnium

If living material is available, watch the contraction of the colony. Are the individual cells independent? If live material is not available, examine preserved material to see the structure of the

contractile fiber in the stalks. How is it different from Vorticella and Carchesium?

Epistylis

If the living material is to be had, study the colony from the standpoint of contractility. If not, examine preserved material for the contractile fibers. Compare with the other types studied.

* *Sketch two or three individuals of Carchesium, Zoothamnium,*
* * *and Epistylis, to show especially the contractile fiber relations.*

EXERCISE 10

Cell Colonization and Differentiation

It has already been pointed out that certain organisms are called plants by botanists and are called animals by zoölogists. Among these are Gonium, Pandorina, and Eudorina. Since they represent a good series of colonial forms, they should be examined, if available, and observations made, concerning shape of colony, number of cells in colony, method of locomotion, and any observable difference in cells.

⁂ *Sketch such forms as observed.*

Anthophysa

This is a colorless colonial flagellate. The colony consists of a branching stalk, reddish in color. At the ends of branches occur spheres of colorless cells. Sometimes the colorless spheres are to be seen rolling along in the water. Details of the individual cell will be difficult to observe, but a little study of the rolling colony shows it to be propelled by flagella on each cell. Can you see any difference in the cells of the colony? Stain with iodine and reëxamine.

⁂ *Make a sketch showing stalk, and a colony of cells.*

Volvox

This organism is typically a plant, and it is used solely to illustrate the simple differentiation of cells for specific purposes. Remember that in colonies of protozoa each cell often carries on all the life processes.

Examine a slide of Volvox under the low power of the microscope. Observe three types of cells in the colony; the bulk of the network of cells consists of somatic cells; the large cells (macrogametes) are the female reproductive cells, the ova; the very small cells (microgametes) are the male reproductive cells, the sperm. The union of the egg and sperm nuclei is called fertilization. Within the cavity formed by the somatic cells may be observed new colonies. These colonies arise from germ cells which develop without fertilization (parthenogenesis).

Examine a slide of a cross-section of Volvox. Observe that the cells are at the surface, thus forming a hollow sphere. Find colonies developing inside the large colony wall. Locate the microgametes and the macrogametes.

⁂ *Make a sketch showing what you have observed in the toto (first observed) mount. Sketch a cross-section showing what you have observed.*

Note. If living material is available, study the method of locomotion.

EXERCISE 11

Cell Differentiation

Cell differentiation has already been studied in Volvox in which two different kinds of reproductive cells occur, in addition to the cells which carry on all the other processes. Such cell differentiation becomes quite extensive in higher animals.

This is perhaps best illustrated in cross-sections of small animals or of embryos. Secure a slide showing such cross-section. If the material is favorable, a considerable variety of cells and tissues (aggregates of similar cells) will be clearly differentiated. Surrounding the entire section, will be the skin. Note the type of cells. Are there any other cells which appear like them?

Find a comparatively large oval structure with a cavity in it, lying almost against the skin. In your specimen this will be at either the right or left side of the section since the embryo is lying on its side. This structure is the central nervous system, in most sections it is the spinal cord, and it is made up of two types of cells which are easily differentiated. It lies in vertebrates on the dorsal (back) side. Just below (ventrad) the nerve tube is the notochord, a circular structure made up of very large, transparent cells.

Other structures such as muscle cells, secreting cells (glands), the alimentary canal, cartilage, and blood vessels will be pointed out by the instructor.

* *Make an outline sketch including the various differentiating*
* * *tissues observed.*

EXERCISE 12

Tissues are composed of a number of similar cells all having a similar function. Several kinds of tissue are easily recognized, such as nervous tissue and muscular tissue. Epithelial cells, which compose epithelial tissue, have already been studied.

Tissues

For a study of the general structure of tissues, muscular tissue is satisfactory.

There are two chief kinds of muscular tissue: (1) striated and (2) non-striated.

Secure a piece of fresh muscle, place it on a slide in a drop of salt solution and carefully separate (tease) the fibers as much as possible. Put on a cover slip and examine under the microscope, making out as much detail as possible. Now replace the salt solution with distilled water and reëxamine. Replace the water with methyl green solution and reëxamine the muscle. During the procedure the following should have been observed: a thin membrane (sarcolemma) surrounding fiber; many nuclei without individual cell walls; longitudinal fibers (fibrillae); sarcoplasm separating the fibrillae; transverse dark lines which separate the fiber into sarcomeres.

* *Draw fresh tissue and tissue showing detail after methyl green*
* * *has been used.*

See demonstration of non-striated muscle fibers. Compare striated and non-striated muscles.

Sponges

The sponges belong to the Phylum Porifera. They are comparatively simple and primitive. They are made up of tissues but have no organs.

Grantia

Secure a specimen and examine it under the tripod microscope. Find the base by which the sponge was attached and, at the opposite end, note the opening (osculum). Observe numerous pores or small openings over the surface. Split the specimen lengthwise and try to determine the function of the osculum and the pores and their relationship.

* *Sketch.*
* *

If sections are available, study the cellular structure. The cells lining the cavities are for the most part flagellated and are of a peculiar "collared" structure. They are separated from the

epithelial cells of the outer surface by mesoglea cells in which are embedded the reproductive cells as well as some "wandering cells."

If sections are not available, study the chart or lantern slide for anatomical details.

In the preparation of sections the spicules which form the "skeleton" of the sponge are dissolved. Take a small bit of Grantia and tear it apart in a drop of water. Cover and examine. Two types of spicules will be quite common: a long slender type and a triradiate type.

⁂ *Sketch.*

Examine the demonstrations of the various types of sponges.

Organs

All degrees of complexity, from the standpoint of tissue composition, occur in organs. The relationship of various tissues to each other may be understood without involved study by examining cross-sections of an intestine.

Secure a slide of this material and observe it under the low power (use high power when it is necessary to get detail). The outer layer is of connective tissue. Beneath is a layer of longitudinal muscle fibers which do not look like the fibers previously studied since they have been cut cross-wise. Beneath this is a layer of circular muscles. Are they striated or non-striated? Under this is connective tissue again. This contains blood vessels and lymph spaces. The former are most easily recognized by their muscular walls; they may also contain blood corpuscles. The innermost layer is made up largely of epithelial cells. Most of these are secretory but some are ciliated. Nerve fibers penetrate the various tissues but are not stained and therefore are not seen.

⁂ *Draw.*

EXERCISE 13

Coelenterata

The animal (Hydra) to be studied has two fairly distinct epithelial layers in addition to reproductive structures which are quite evident in some specimens, and the nerve cells which are observed only with the finest technique of staining. It belongs to a group of animals known as coelenterates.

If living specimens are available, note their method of locomotion, feeding, and other activities. Examine a slide of a toto (whole) mount under the low power. Note the number of tentacles. Find the peristome (an elevation surrounding the mouth), buds, spermary or ovary.

 * *Make a sketch of Hydra.*
* *

Examine a longitudinal section through a bud. What is the relationship of the bud to the parent? If your section does not show the mouth, examine the demonstration slide showing this structure. Observe any differences of cell structure. Are the similar cells grouped into layers? Observe the balloon-shaped structures in some of the cells in the outer surface. If possible make out their structure. These are nematocysts. In favorable sections the sex structures may be seen. If you do not find them in your specimen, examine them on the demonstration slide.

 * *Sketch, showing the gastrovascular cavity, ectoderm, endoderm,*
* * *bud, and any other structures observed.*

EXERCISE 14

Alternation of Generations

Among animals, some of the coelenterates show well the type of "alternation of generations" known as metagenesis. An organism which is sexless produces by asexual reproduction, organisms which are sexual. The latter produce male and female germ cells which combine during fertilization, and the resulting organism is sexless. The cycle is then repeated.

In the asexual form, certain of the coelenterates grow in colonies in an attached condition; that is, they are sessile. In these colonies there are at least two types of polyps, or individuals; one type is concerned with getting food (hydranth), and the other type (gonangium), is more fully concerned in producing new, free swimming individuals (medusae).

Obelia

This coelenterate is an excellent one in which to study asexual reproduction.

Examine a colony, identifying the hydrorhiza, from which arise, at right angles, the hydrocauli. The latter branch, in some cases terminating in a cup-like, or hydra-like structure (the hydranth), in others, in a cylindrical vase-like structure (gonangium), in which a central rod (blastostyle) may be seen. Upon the blastostyle, in mature gonangia, small medusae may be seen. These are liberated through the terminal opening of the polyp, and they swim away to produce germ cells which, after fertilization, grow into a new colony like the one under observation.

How does the gonangium get its food?

Why does this animal produce medusae?

* *Draw a composite sketch of a colony of these animals including*
* * *various types that have been observed.*

Gonionemus

Examine the demonstration of the medusa of Obelia. These are so small that it seems best to make a study of Gonionemus medusae, which are much larger. Secure a specimen. Because it looks somewhat like an open umbrella, the spherical surface is called ex-umbrella and the flat surface is spoken of as the sub-umbrella. The mouth is on the sub-umbrella side and this region may then be spoken of as the oral side, while the ex-umbrella is the aboral side. Observe the number and distribution of tentacles; the radial canals extending from the central structure (manubrium) which corresponds to the handle of the umbrella. Find the shelf-like structure (the velum), on the oral side and examine the radial canals for the reproductive organs.

* *Draw a sketch of Gonionemus, including all structures observed.*
* *

Portuguese Man-o-War

Examine the demonstration, and from a study of the text, charts or lantern slides, try to get an idea of this colony of coelenterates.

Jelly Fish

The animals just examined belong to the Class Hydrozoa which is characterized by somewhat comparable development of the two forms nutritive and reproductive. The jelly fish which is now to be examined is a scyphozoan. In this group the medusae are much more important than the polyp. Examine the demonstration. Note the similarities to the medusae of Gonionemus and Obelia.

Sea Anemone

This animal belongs to the Class Anthozoa, which is characterized by the absence of medusae. Examine the demonstration of this animal. It appears to be made up of separate compartments, but all are connected.

Corals are colonial anthozoans. Examine coral.

Details of structure of any of the foregoing animals may be seen on the charts or lantern slides.

* *Write a definition for this Phylum which will include all the members that you have studied.*
* *

EXERCISE 15

Platyhelmia

The organisms which are now to be studied are elongated, flattened, bilaterally symmetrical animals, having a definite anterior region.

Planaria

Secure a specimen of Planaria and observe its method of locomotion. How can you distinguish this animal from an infusorian? See if you can find the proboscis, a tube on the ventral side through which food is sucked up. The pigmented bodies, the "eyes," on the dorsal side near the anterior end are readily seen. Note their shape. Is this animal radially or bilaterally symmetrical? Why? The internal structures will probably not be evident in the living specimen.

Examine a toto mount. In the central area there is a tubular structure, the proboscis. This lies in a sheath within the body but can be extended through the mouth. How this may be done is best seen in sagittal sections to be studied later. Is the attachment of the proboscis posterior or anterior? Trace the digestive system from the base of the proboscis. The extent of the lumen (cavity) is indicated by the lighter stains. Why is this animal spoken of as a triclad? The projections at the side of the head are called auricles. They are not ears, but tactile organs.

* *Make outline drawing showing the structures observed.*
* *

Examine a sagittal section and observe the relation of the proboscis to the gastrovascular cavity and to the pharyngeal chamber. If your specimen does not show the mouth, examine a specimen that does. Try to understand how the proboscis is extruded through the mouth.

* *Sketch showing structures observed. Examine charts, demon-*
* * *strations or lantern slides for the location of the reproductive structures.*

EXERCISE 16

Platyhelmia

Parasitic animals are often quite modified as compared to the primitive type of the group to which they belong. The planarian, studied in the last exercise, is a rather typical example of a free living flatworm. The exercise of today is devoted to the study of flatworms which have become parasitic, and hence show modified structures.

The Liver Fluke

Clonorchis sinensis Cobbold occurs in man and in other animals, particularly in China and other Oriental countries. It lives in the hepatic and pancreatic ducts. Several thousand of these parasites may occur in one individual host. Obtain a stained preparation of this trematode worm and study it under the low power of the microscope. As you study, keep in mind a comparison of this parasite with the free living planarian that you studied during the last period. Locate the following structural features:

(a) The cuticle over the outer surface.

(b) The enteron consisting of an oral sucker, pharynx, and intestinal crura.

(c) The acetabulum, or ventral sucker, at about the end of the anterior quarter of the body.

(d) The male genital system: two branched testes near the posterior end; a duct (the vas deferens) leading forward from these; an expanded seminal vesicle in the course of this tube; and a genital pore just anterior to the acetabulum.

(e) The female genital system: an ovate ovary anterior to the testes; numerous small vitelline (yolk) glands along the sides of the body; vitelline ducts from the glands to the ovary; a seminal receptacle just behind the ovary; a shell gland in front of the ovary; a coiled uterus which contains eggs and leads to the genital pore in front of the acetabulum.

(f) The excretory system, which opens through the excretory pore at the posterior end.

(g) The nervous system is a reticulate system of nerve cells. A ganglionic mass may be seen just behind the pharynx.

* *Make a drawing, including all the details which you have ob-*
* * *served.*

Trematode Life History

Examine the demonstration of a Clonorchis egg, sporocyst, cercaria, and metacercaria, and understand the relation of these to the life history of trematode worms.

Tape Worm

Taenia pisiformis Block is a tape worm which commonly lives in dogs. Study a mature proglottid and draw it to show organs which are quite similar to those you observe in the trematode. The genital pore will be found on one margin. The two ducts, the vas deferens and the vagina, may be traced from this to the genital organs. There are numerous testes scattered more or less throughout the proglottid. The ovary and vitelline gland are lobate, the shell gland is globular and fuzzy, and the uterus extends longitudinally through the middle of the proglottid.

Under the low power of your microscope, study the scolex of a tape worm. For what is it fitted?

Life History of Tape Worm

Examine demonstrations of the tapeworm "egg" (containing an onchophore larva) and of a cysticercus (bladder worm).

EXERCISE 17

Nemathelmia

The difference between the flat worms and the round worms is possibly greater than the difference between Hydra and Planaria. The nematodes, which represent the bulk of this group, are to a great extent parasitic, and it is difficult to get much information from books concerning the primitive, free living forms.

Nematodes

Secure a specimen and observe how it moves about. Is this motion like that of a snake or an earthworm? Remove as much of the grit as possible from the slide and cover with a long cover glass. Remove all surplus water so that the cover glass presses down on the worm. Examine under the low power. Note that the body is covered with a heavy cuticula. This is not as rigid as it appears and is easily injured by careless moving of the cover glass.

No difficulty will be encountered in differentiating two regions of the body. There is a clear anterior portion which is separated from the much more darkly colored portion.

The anterior part contains a tube, the esophagus, which extends from the mouth to the cardiac valve, a structure which separates the esophagus from the intestine. The mouth is armed with spines which, in certain parasitic forms, have become highly modified and important. Determine, as far as possible, the number and position of the spines. There may be an enlargement of the tube immediately posterior to the mouth; this is the pharyngeal cavity. The intestine occupies the bulk of the cavity of the body. Its extent may be determined by watching the movement of food within it. It opens through the anus. Doubtless you will see this animal egesting waste.

The excretory system consists of a bag-like structure (ventral gland) lying alongside the intestine, with a tube leading forward and opening about two-thirds of the way back on the esophagus.

The nerve ring encircles the esophagus just a little anterior to the middle. Reference to texts will have to be made to determine the location of the longitudinal nerve fibers since they cannot be seen in these specimens.

The sexes are separate. The female can be most easily recognized by the vulva which is very distinct in the species under observation. This structure is the only opening between the cardiac valve region and the anus. The male is most easily recognized by the absence of the vulva. Examine both male and female specimens.

The vagina is single; leading to the uterus, an enlargement of which, the seminal receptacle, may or may not be observed. Large or small eggs may be seen in the uterus. The ovary is more difficult to identify.

In the male, the testes lie about midway between head and tail. A duct, the vas deferens, leads caudad to the anal opening. The intromittent organ (spicules) may or may not be observed.

* *Draw a generalized figure of either the male or female, including*
* * *such structures as have been observed.*

If you have time, observe other nemas.

Note. See Ward and Whipple—*Fresh Water Biology* for a discussion of nematodes.

EXERCISE 18

Nemathelmia

The roundworms do not fall clearly into groups which are largely free living or parasitic, as the flatworms do. All of them have a resistant cuticle on the outside of the body and this covering enables them to live in media which would be fatal to most small animals. Certain species live in solutions of acids or salts; others flourish in putrifying substances; some live as parasites in the bodies of plants or animals. The life histories of some parasitic species are quite simple; those of others are quite complex and may involve passage through various hosts. Among the nematode parasites which infest man, perhaps none has more interest than the hookworm.

Hookworm

Ancylostoma duodenale Dubini lives in the intestine of man and, if present in sufficient numbers, may cause hookworm disease (ancylostomiasis). Obtain a slide which contains a mounted male and female, and study carefully under the low power of the microscope.

* *Draw one individual to show mouth, cuticle, reproductive or-*
* * *gans, and anus.*

State the sex of the individual you have drawn.

* *Make a drawing of the posterior end of the other individual*
* * *which you have on the slide. Show your drawing to your instructor and he will give you the names of the structures you have drawn.*

Life History of Hookworm

Examine demonstrations of hookworm eggs and larvae, and of specimens of other parasitic nematodes. Look up life history of the hookworm.

Trichina

Examine the demonstration of Trichina. Note that the larval worm is coiled up in a cyst in a striated muscle fiber.

EXERCISE 19

The animals now to be studied are divided externally into a series of ring-like structures (annuli); hence the name Annulata, or as more often given Annelida. The annelids are bilaterally symmetrical and have a more highly developed nervous system than the flatworms. The type to be studied has little bristles sticking through the skin; such animals are called chaetopods (bristle-foot).

The Earthworm

Secure a living specimen. Examine the anterior and the posterior ends, observing any difference in form and structure. Allow the worm to crawl on your hand or on the table, and watch until you are sure just how it moves. What keeps it from slipping backward when the anterior end is pushed forward? Drag it over your finger and feel the bristles. Is the worm sensitive to light? Devise a plan to determine this point and test it. Can you find any eyes? Ears? If the worm is not clean, rinse under the water tap. Now examine the pulsation of the blood vessels. Which way does the blood flow on the dorsal side; on the ventral side? How does the blood get from one vessel into the other? Where do you suppose the slime comes from that covers the worm? What is its purpose?

Return the worm to the container and obtain a preserved worm for the following observations: Using your hand lens, locate the bristles (setae), note their number and the arrangement. There are openings near the setae which are used for the removal of waste. Observe any other openings on the ventral side and determine the somites (counting from the anterior end and omitting the prostomium) on which they occur. These will be referred to again when the study of reproductive organs is taken up.

Examine the lip (prostomium) which overhangs the mouth. What do you suppose its function to be?

* *Place the animal on its side and draw the anterior fourth, being*
* * *sure to put in structures on the proper segments.*

With your razor knife, split the worm lengthwise just a little to one side of the middle line. Examine the cut surface. The central tube is the digestive tract (alimentary canal). The anterior part with heavy wall is the pharynx; the thin walled part following is the esophagus or gullet; this latter expands into a crop which in turn is followed by a muscular gizzard. The latter leads into an intestine which runs directly to the posterior end and opens to the outside through the anus. How is the surface area of the intestine increased without increasing its length? What would you say is the diet of an earthworm? Can you suggest a plan to find out?

⁂ *Draw an outline of the body wall of the anterior part of the earthworm as seen in this view, including a few somites beyond the gizzard. Now put in the digestive organs in outline, being sure to locate the organs in the proper somites.*

Taking the larger half, very carefully remove the alimentary canal. This should leave the dorsal and ventral blood vessels, as well as all other organs in position. Find some large blood vessels, (blood rings) connecting the two large, longitudinal vessels. Note carefully their position. Which way does blood flow through them? Are they hearts? If you cannot tell, examine a living worm once more.

⁂ *Draw in the blood vessels on your drawing, being sure to place the so-called "hearts" in the proper somites.*

Examine the ventral wall for some glistening fibers. These are nerves. The "knots" in each of the somites are ganglia. Examine with tripod magnifier and note any detail. Is the nerve single or double? Trace cephaled (toward the head) and find the ganglia (sometimes called the brain) over the esophagus. Do you see anything peculiar about the "brain" under your tripod magnifier? Did you trace the fiber on each side of the esophagus to the "brain"? Explain.

⁂ *Sketch in the nervous system as you have observed it.*

Examine the partitions (septa) between the somites for small tubes which penetrate them. Those opening to the outside near the setae are nephridia, or organs of excretion. Trace them back into the body and note the shape of the free end. How do you suppose they can eliminate waste products? Is there any connection between the nephridium and the intestine? What kind of waste could the nephridia eliminate? What organs in higher animals eliminate this kind of waste? Do nephridia occur in all somites?

⁂ *Sketch the nephridia into your drawing.*

The reproductive organs may be found by tracing the tubes from their exits back to the organs. Both male and female organs are present in the one animal (hermaphroditic). The two pair of testes lie inside the two posterior seminal vesicles which are the large structures lying anterior to the ovaries. Find all the organs mentioned.

⁂ *Sketch the reproductive organs into your drawing.*

EXERCISE 20

Annelida

There are many annelids besides earthworms. Some live in fresh water, some in salt water, and others live in damp earth.

Secure a drop of water from the culture, being careful to get some of the muck. Examine for chaetopods. The ones you find will probably be Dero. Look over your specimen, noting any similarities to and differences from the earthworm. If you are lucky, you may observe an unusual method of reproduction; namely, one worm separating into two parts, a new anterior end being formed about the middle of the body. If this is observed, call the instructor.

Examine Nereis, paying special attention to the paired segmental appendages (parapodia). Find the chitinous jaws and the eyes. Examine the tentacles, and observe their locations. Study a parapodium, trying to understand its structure which is to be compared later with somewhat similar organs in Peripatus.

Compare this animal with the earthworm.

Secure and study a leech. In what ways is it like an earthworm? In what ways does it differ? Locate the posterior sucker disc and also the oral sucker which contains the mouth. Examine the structure of the mouth. How does a leech "draw blood"? Examine the demonstration of the dissection of a leech to determine the relation of internal to external segmentation.

⁂ *Illustrate by sketches any observations you have made.*

⁂ *Complete the chart and transfer to your note book.*

Animal	Body Regions (Names)	Eyes*	Setae*	Parapodia*	Means of Attachment
Dero					
Earthworm					
Nereis					
Leech					

Animal	Modified Mouth Structures—Name and Function	Internal Segmentation = External. Yes or No
Dero		
Earthworm		
Nereis		
Leech		

*P = Present. A = Absent.

EXERCISE 21

Arthropoda

These animals have an exoskeleton and jointed appendages which are more or less efficient organs of locomotion. They do not have a backbone. In some groups the body is divided into three easily differentiable regions, namely, head, thorax and abdomen; in others the head and thorax have fused into a cephalothorax; in others the thorax and abdomen are not separable, hence the animal has only a head and body; and in still others no regions of the body, whatsoever are differentiable. The paired segmental appendages which probably served as locomotor organs in the primitive arthropod have become adapted in a number of cases for other purposes. The four classes of land living arthropods can be separated from one another on the basis of the modifications of these segmental appendages and their methods of breathing. The fifth group is water living and is separated from the others by the presence of gills for breathing.

Class Onycophora

Peripatus

The simplest of these arthropods is Peripatus. Each appendage bears two claws. The scarcity of this animal makes it impossible for each student to have one for study. Examine the demonstration specimen and then study the chart or lantern slide. In what ways does this animal resemble the annelids? In what ways does it differ? Are there appendages on every somite (body segment)? Have any of the appendages been adapted for functions other than locomotion?

Class Myriapoda

Centipede

Examine a specimen, determining the distribution of the appendages. Compare the structure of the appendages of this animal with those of Peripatus. Examine a slide of the mouth parts of the centipede. These consist of a pair of mandibles, two pairs of maxillae, one of which is fused, and a labrum. The poison claws (maxillipeds) represent the first pair of body appendages.

* *Draw the mouth parts.*

* *

Class Crustacea

Sow Bug

This animal may be found by turning over rocks, logs or old boards.

Secure a specimen and examine it for modification of appendages. Are any pairs of them missing, assuming that a pair should be present for each somite of the body?

Examine the mouth parts carefully. The plate-like maxillipeds, as you will observe, overlie two pairs of maxillae and a pair of mandibles. The single pair of antennae are quite evident. You may find another rudimentary pair. See if any of the posterior appendages have been modified. Examine the eyes. Can you recognize three distinct regions of the body? Is your specimen male or female? Compare your specimen with others to settle this question.

Class Insecta

Cockroach

Examine a specimen, paying special attention to the structure, distribution, and modification of the paired segmental appendages. Examine also the mouth parts. These may be a little more difficult to observe than in some other animals so they should be removed carefully one at a time. The paired maxillae are easily recognized since they are branched; the mandibles are horny with jagged teeth; the labrum is single; the labium is median and single at the base but double at the extremity. How do these mouth parts compare in structure and function with the mouth parts of arthropods which have previously been studied?

Class Arachnida

Spider

Note that in the spider there are only two body regions. Which have fused? Note the number and location of legs. The most anterior mouth parts are chelicerae: the next are pedipalpi. How do these compare with the mouth parts of other arthropods?

* *Fill out the chart on page 46 and transfer to your note book.*
* * *Where body regions have not differentiated, or where they have fused, use a bracket to indicate the undifferentiated or fused parts.*

* *Using only the information on the chart, define: Arthropoda,*
* * *Onycophora, Myriapoda, Crustacea, Insecta, Arachnida.*

	Animal				
	Peripatus	Centipede	Sowbug	Cockroach	Spider
Number of somites					
Head					
Thorax					
Abdomen					
Number of paired appendages					
Head					
Thorax					
Abdomen					
Function of appendages					
Head					
Thorax					
Abdomen					

EXERCISE 22

The study of the internal structure of the Arthropoda will be based upon (1) an aquatic species, a crustacean (the crayfish), and (2) a land-living species, an insect (the grasshopper).

Crayfish

Examine a living specimen, observing how it moves, responds to stimuli such as light and touch; how it eats, and if possible how it breathes (see later in the text).

Secure a preserved specimen and carefully remove the carapace (shell) from one side of the anterior half of the body (cephalothorax), being careful not to injure any of the underlying structures. Observe the plumy structures, the gills, and observe how and where they are attached; note also their number. These organs serve for breathing (respiration). How can animals breathe in water? How is the water forced over the gills? This question can best be answered by placing a drop of ink near the last thoracic legs and close to the body of a living crayfish and putting it in water. Reëxamine your preserved specimen for organs which induce the flow of water over the gills. Remove the gills and expose a membrane; then remove this, exposing the underlying structures. Find the stomach. Trace the alimentary canal forward to the mouth; remove the shell from the abdomen and trace the intestine backward to the anus. Observe the two compartments of the stomach and any peculiar construction in each. What keeps large particles from passing into the posterior (pyloric) part of the stomach? How is food ground in the anterior (cardiac) part of the stomach? Are there any digestive glands emptying into the alimentary canal?

* *Make an outline drawing of the body of a crayfish (side view)*
* * *without the appendages. Add an outline of the digestive system.*

Directly over the stomach, find the heart which is encased in a bag-like structure (pericardium). Trace the blood vessels forward and backward. One large vessel extends ventrad and is of especial interest because it passes between the two strands of the nerve cord. Remove the heart from the pericardium and see if you can find small openings through the walls other than those of the blood vessels. These are ostia. Can you determine their functions?

* *Sketch the heart and attached blood vessels, so far as you were*
* * *able to trace them, into your drawing.*

Anterior and dorsal to the stomach, find the green glands. Find a duct leading from each. Where does it empty? Cut one

of the glands lengthwise. Are there two distinct parts? These glands eliminate waste materials. Compare in function to the nephridia of the earthworm.

* *Sketch a green gland and its duct into your drawing.*
* *

The reproductive glands should be just posterior to and above the stomach. They may lie partly between the heart and the stomach. If you cannot find them, look for openings in the bases of the third (female) or the fifth (male) pair of walking appendages. Now find the tubes and trace to the reproductive gland. Examine a specimen of each sex.

Observe that in the male the first abdominal appendages are modified into copulatory organs for transferring sperm to the female. In the female there is a cup (seminal receptacle) in the shell between the fourth and fifth pairs of walking legs into which the sperm are placed.

* *Sketch the reproductive system into your drawing.*
* *

Find the nerves and trace them forward around the esophagus to the so-called brain. Look for ganglia along the nerves. Exactly in what segments do they occur? Are they any different than in the earthworm?

* *Sketch the nervous system into your drawing.*
* *

EXERCISE 23

The locust (grasshopper) will serve well as an example of the terrestial arthropods. Living on land calls for quite different types of organs for carrying on life processes. For example, gills would not serve as respiratory organs for the insect, while wings for locomotor organs would be useless to crustacea. In the locust such modifications have occurred as to make them an interesting example of arthropods which have become adapted to living upon land.

The Locust

If live specimens are available, they should be studied both as to modes of locomotion and manner of eating. But first, secure a preserved specimen and compare the body divisions with those of the crayfish. Are there appendages on each somite? Are all appendages similar in construction; that is, do they have the same number of segments?

Remove the wings on one side, noting the somites to which they are attached, and find the auditory organ just above the articulation of the hind leg with the body. Note its shape. What is its function? How do locusts sing?

Just anterior to the auditory organ, find a small opening (spiracle). Another may be observed above the second leg and still others along the sides of the abdomen. These are external openings of a series of tubes used for breathing. The network of tubes should be examined when the body is opened.

Examine the eye under your tripod magnifier; does it look like a honey-comb? Each facet is a separate eye. How does the animal see? Such eyes are called compound. Eyes like those of man are simple.

Split the shell of the locust along each side and then remove the dorsal part, being careful not to injure any of the underlying structures. A dorsal blood vessel (which may be called a heart), composed of segmental enlargements, should lie on the exposed surface. Trace it as far as you can.

At the anterior end of the body is a large sac (the crop) connected with the mouth by a short tube (esophagus). The crop narrows at its posterior end, and then leads into the stomach. Lying around the stomach and gizzard are some cylindrical bodies (caeca); tease one away and see that it opens into the alimentary canal. These are digestive glands. The intestine is short. Carefully remove the crop and find the salivary glands; trace the tubes leading from them. Where do they empty?

* *Sketch an outline of the grasshopper from the side omitting*
* * *the appendages. Draw in the circulatory and digestive systems.*

At a point where the stomach opens into the intestine, look for a number of long, thread-like structures (Malpighian tubules) which extend forward into the body. These serve as excretory organs. Where do they empty? Compare the organs of excretion of the grasshopper with those of the crayfish and the earthworm.

⁂ *Sketch the Malpighian tubules into your drawing.*

The reproductive organs lie just dorsal to the stomach. In the female, the glands (ovaries) may be quite large and eggs may be observed in them. Find the tubes leading away and trace them to their openings. If your specimen is a male, examine a female belonging to some other student in the section. The male glands are more difficult to find. They usually lie on the intestinal wall just posterior to the stomach. Trace the duct to its outlet.

⁂ *Draw in the reproductive system.*

As in the crayfish and the earthworm, the nerve cord is ventral. Observe its double structure; observe the location and size of the ganglia.

⁂ *Add the nervous system to your drawing.*

EXERCISE 24

Economically Important Insects

There are literally thousands of insects which are economically important; some because they are useful, others because they are injurious. This exercise attempts to acquaint the student with a few of the latter.

Plant Lice

Many plant diseases are due to the presence of insects which suck the juices and injure the plant. Among these are plant lice. Examine some of the fuzzy deposit upon twigs. Remove some of the fibers and you will find an aphid hidden beneath. Examine a specimen, noting particularly the mouth parts. See how they are adapted for their manner of living.

Scale Insects

Animals belonging to this group, after attaching themselves to the bark, fruit or leaves of trees or shrubs, secrete a wax in which the cast off skins become imbedded forming a scale-like structure which has given rise to the term scale insect. The insect lies underneath the scale.

Secure a piece of infected wood and examine the insect. Refer to texts for methods of reproduction and for the life histories. If any other scale insects are available, examine them.

The Tobacco Worm

This larva is very destructive to tobacco leaves. Examine a specimen paying especial attention to the mouth parts. Are they adapted for biting or sucking? The horn on the posterior end is not a ''sting.''

The Potato Beetle

This is another animal which is especially harmful. Originally it fed on weeds. Examine an adult, paying especial attention to the mouth parts.

Cotton Boll Weevil

Examine an adult, especially the mouth parts. The eggs are laid in the bud of the cotton, hatch there and the larva feed on the tissues, thus destroying the boll.

* *Using only the information obtained from studying the above*
* * *specimens and deductions which can be made logically therefrom write a short composition (1-2 pages) on Economic Importance of Insects.*

EXERCISE 25

Life Histories of Crustacea

The life histories of a number of animals show that the free living young are frequently quite different from the adults; so different, in fact, that one unfamiliar with them would not consider them as being related. The crustacea furnish many examples of this, and we are now to study some of them.

Copepod

The copepod is a crustacean, some species of which may be found in almost any pool of water. In respect to distribution, they seem to be worthy rivals of the nematodes.

Secure from the culture an adult specimen. Note the shape of body and the method of locomotion. Females may have egg sacks extending back on either side of the abdomen. There is a median dark colored eye. The antennae as well as the first abdominal appendages may be highly modified in the male for clasping during copulation. The eggs are carried until hatched. The larva which emerges from the egg does not resemble the adult very closely, and is called a nauplius.

If living material is available, mount on a slide and observe the manner of locomotion. Study the appendages. Three distinct pairs of appendages are present, the middle pair of which are distinctly forked. The fourth pair is represented by spines. At an early moult, these latter give place to typical embryonic appendages.

After a number of moults, other appendages appear. Examine a specimen showing additional appendages but one in which the regions of the body are not yet differentiated. This is called a metanauplius. As soon as body regions are differentiated, the stage is considered as an early adult. Find such specimen and observe the appendages.

* *Fill out the chart on page 53 and put in your note book.*

* *

Appendages present*	Nauplius	Metanauplius	Early Adult
First Antennae.....			
Second Antennae...			
Mandibles.........			
Maxillae...........			
Maxillipeds........			
1st. Swimming.....			
2nd. Swimming.....			
3rd. Swimming.....			
4th. Swimming.....			
Body Divisions†....			
Head..............			
Thorax............			
Abdomen..........			

*These are arranged in order from the anterior end backward.
†P=present, A=absent.

Crab

The transformations in the crab are even greater than those of the copepod.

Examine male and female adult crabs, paying attention to the appendages. Keep these structures in mind while examining earlier stages.

Secure a zoea stage and compare the appendages and general form with that of the adult. Are the same body segments evident as in the adult?

Secure a megalops stage. Make comparisons with zoea stage and adult.

* *Write a brief story of the metamorphosis of the crab.*

* *

Barnacles

Some of the crustacea have degenerated. Among the most typical of these are barnacles. Examine some of the specimens. Secure a "goose-barnacle" and examine it. Would you think it to be an arthropod? Why? Remove the shell and examine the enclosed organism. What evidence is there that it is an arthropod?

The young barnacles pass through stages that are similar to those of some of the copepods.

EXERCISE 26

Life Histories of Insects

The life histories of insects are extremely varied; the larva and pupa are sometimes so different from the adult that they would not be considered as belonging to the same group of animals, by one untrained in zoölogy. The life histories will be illustrated by several diverse types.

The Fly

Examine an adult fly, noting the legs, wings, mouth parts, and segments of the body. Keep these in mind as you examine the following specimens.

The common fly lays eggs in decaying animal or vegetable matter. The specimens that are being examined came from eggs that were laid on meat. In warm weather, the eggs hatch rather quickly into maggots. Secure one of the maggots and see if you can find any structures similar to those found in the adult such as legs, wings, eyes, or mouth parts. Is the body segmented? At the anterior end, but within the body, find a rather rigid structure, the cephalopharyngeal skeleton. Note its shape from above and from the side. At the posterior end, on the flat surface, note two reddish ovoid spots, the anal spiracles. Trace the tubes leading from them as far forward as possible. What is the function of this system?

* *Make a sketch including the structures that your have observed.*
* *

After several moults, the maggot enters the ground. A hardening of the skin occurs and forms the puparium. The animal is now spoken of as a pupa. Secure and examine a puparium. Carefully open it and examine the pupa. In what ways is it different from the maggot or larva? What further changes would be necessary for it to resemble the adult? Examine some of the puparia from which adults have emerged and note how this was accomplished.

* *Write a short paragraph on the life history of the fly, using such technical terms as you have learned.*
* *

The Mosquito

This animal is selected because its larval life is spent in water. The eggs are laid on the surface of still water and they hatch into "wigglers," or larvae, such as are often seen in rain barrels and small pools.

Secure a larva and examine it. If living specimens are available, study the method of locomotion. Watch the animal as it comes to a resting position. Why does it stand on its head when it comes to the surface of the water? Can you trace any tubes from

the prong (siphon) which comes to the surface? What life process is being carried on by this structure? Watch the animal eat; see how food is taken in. If possible, see what serves as food.

* *Draw a larva.*
* *

Secure a pupa of the mosquito. If living specimens are available, study their locomotion. Note the resting position at the surface of the water. Why does it differ from that of the larva? The breathing tubes come to the surface. The eyes will be visible as elongated black bodies; the wings, as small flat folds. The legs are just anterior to the wings while the antennae are just anterior to the eye.

* *Diagram and label. Write a paragraph on the life history of*
* * *the mosquito, using technical terms.*

Other Insect Life Histories

Study mounted specimens showing the life-histories of moths, butterflies, or beetles. These insects, like the house fly and mosquito just studied, undergo a complete metamorphosis in transforming into adults. The fully matured insect shows no resemblance to the larval form. There are four stages in the life cycle; the egg, the larva (feeding stage), the pupa (resting and transforming stage), and the adult.

For comparison with insects showing complete metamorphosis, examine preparations showing life-histories of cock-roaches, grasshoppers, squash bugs, or cicadas. Note that there is no pupal stage; the change to the adult being gradual. The immature forms, or nymphs, undergo a series of moults and after each moult look more and more like the adult. This type of transformation is spoken of as incomplete metamorphosis. There are three stages in the life cycle: egg, nymph (immature forms), and adult. Most of the lower orders of insects undergo incomplete metamorphosis, while the more specialized groups show complete metamorphosis.

In some insects (Aptera—such as the fish moth) the young when hatched are like the parents in general structure.

EXERCISE 27

Polymorphism in Insects

Among arthropods there is frequently a wide difference in the appearance of the male and the female. In some moths and butterflies the wings of the male are entirely different from those of the female. Abdominal markings differ, and appendage differences also occur which often serve as a basis for the "caste system" in ants and bees.

Bees

Examine preserved specimens of drone, queen, and worker bees.

* *Sketch an outline of the body of each, maintaining the relative*
* * *sizes.*

Examine each kind for the "sting." Carefully remove it from a specimen and examine together with the poison gland. Determine how it works. Examine the "dart" or sting proper under the microscope (lowest power).

* *Sketch the sting mechanism.*
* *

Examine the third pair of legs in each caste of the bee. The outside surface of next to the last segment may be cupped and surrounded by bristles. This structure is known as the pollen basket. Scrape it slightly and examine the materials under the microscope for pollen grains. Do all three kinds of bees have pollen baskets? Do they all contain pollen? For detail of the method of pollen collection and use, refer to texts such as Snodgrass, Anatomy and Physiology of the Honey Bee.

Complete the following chart:

	Sting Yes or no	Pollen basket Yes or no
Male		
Queen		
Worker		

Termites

In the termites to be studied there are five different castes in each of which there are both males and females. There are also developmental stages within each caste. Only three castes will be studied: (1) the soldiers; (2) the workers; both non-reproductive; and (3) the first reproductive caste.

The soldier is wingless and has an elongated yellow chitinous head with very large brown mandibles. The head is nearly one-half the length of the body. The worker is wingless with a head and mandibles much smaller than that of the soldier.

The reproductive castes are easily separated from the non-reproductive by their larger abdomens.

Two of the developmental stages of the reproductive caste are easily differentiated.

The nymph is creamy in color, has light brown eyes, and long wing pads (rudimentary wings). The adult has long wings, a dark brown body and black eyes.

Examine the live termites on demonstration.

Study the four preserved termites in your bottle. How many legs does each have? Assign a number to each one and fill in the chart on page 59.

When you have filled in the characteristics of each you will be able from the description given to fill in the last column.

When the chart is completed transfer to your note book.

Specimen Number	Wings (Present, Rudimentary or Absent)	Color of Body	Color of Eyes	Mandible (Large or small)	Kind
1					
2					
3					
4					

EXERCISE 28

Arachnida

The arachnids are widely divergent among themselves. Four kinds are to be examined.

The Spider

Secure a specimen and observe the number of legs. Two body regions, the cephalothorax and the abdomen, are quite evident. Examine the top of the head for ocelli (eyes). Observe the number and position. Examine the mouth parts, and find the poison fangs. Use a lens, if necessary. Examine the mouth. What kind of food would you think is used by the spider? Examine the ventral surface of the abdomen. In the first third, find two lateral transverse slits; these are openings to the lung books. In the median line at about the same level may be seen the opening of the sex glands. Examine several specimens for differences in this structure. Can you separate males from females by it? Near the posterior end of the abdomen and on the ventral side may be seen papillae, the spinnerettes. What is their function? The anal opening is posterior to the spinnerettes.

The Scorpion

Procure a specimen and note the number of walking legs. Compare the segmentation of the scorpion with that found in the spider. Are there poison fangs at the mouth? Examine the terminal segment of the abdomen. This is a poison fang. The openings on the ventral surface on segments posterior to the legs are entrances to "lung books." Find the openings of the sex gland, if possible.

The King Crab

Examine a specimen: the dorsal view permits a distinction between cephalothorax and abdomen. The long spine, the terminal abdominal appendage, is probably homologous to the telson of the crayfish. Note a median and two lateral eyes on the cephalothorax.

Examine the ventral surface. The first pair of appendages are typical mouth parts; the next four pair are walking legs; the next pair "shoving legs." Observe the appendages on the abdomen. These are "lung books." Examine their structure. The large, anterior, over-lapping one is called an operculum. Anterior to its base find a pair of openings, the genital pores. The anus opens just in front of the posterior spine.

Ticks

Examine the prepared slide of ticks. Two animals are mounted on each slide, one showing the ventral side and the other the dorsal. How can you tell the difference? How many legs are there? What sort of mouth parts (biting or sucking) does the mite have? What would this indicate as to its habits?

Complete the table on page 61 and transfer to your note book.

	Spider	Scorpion	King Crab	Mite
Body Regions				
Cephalic Appendages Names				
Thoracic Appendages Names				
Abdominal Appendages Names				
Distinctive Features				

EXERCISE 29

Echinodermata

It is to be recalled that the coelenterates were radially symmetrical while the animals which have been studied more recently have been bilaterally symmetrical. The group of animals (Echinodermata) now to be studied are radially symmetrical but are far more complex than the coelenterates. Because of their complexity and because their larvae are bilaterally symmetrical, many think them to be descended from a bilateral ancestor.

Starfish

Secure a specimen and examine the lower (oral) side. There are grooves running from the center to the tip of each ray. These are the ambulacral grooves. In them may be seen structures known as tube feet, the function and action of which are to be explained by your instructor. At the tip end of each ray is a red or yellowish-red spot which is sensitive to light. It is called an eye but it is not similar to either arthropod or vertebrate eyes. The aboral side has only one distinctive mark, the madreporite. Its function is best understood by studying the chart or a lantern slide showing the internal anatomy.

Examine the dorsal surface with your tripod magnifier. Find small spines surrounded by pincher-like structures (Pedicellariae). Can you think of a function for them? Are all pedicellariae alike?

In general, the internal organs found in any ray are similar to those of any other ray.

 * *Sketch the oral side, showing structures observed.*
* *

 * *Sketch the ab-oral side, showing structures observed.*
* *

Secure specimens of sea urchin, sand dollar and sea cucumber. Are they radially symmetrical? What has become of the rays? What has become of the ambulacral grooves?

EXERCISE 30

Echinodermata

The development of the starfish offers a good example of one type of early embryology, and, in addition, gives an example of the application of the biogenetic law, the radially symmetrical adult arising from a bilaterally symmetrical larva.

Starfish Embryology

Secure a slide showing the egg and early stages of development.

* *Sketch the following: Single cell; 2 cell stage; 4 cell stage; hol-*
* * *low sphere stage (blastula).*

Find an older individual in which a part of the wall has cupped in. Examine specimens from the side and end until you understand the structure.

* *Make a diagram of a longitudinal sections. Of what animal does*
* * *this stage remind you?*

Examine the demonstration of a bipinnaria, which is a stage in the development of the starfish. Could you pass a plane so as to separate it into two similar parts? Could you do the same thing with the adult starfish? What may this indicate?

EXERCISE 31

The molluscs have been left to this position since they include animals showing extremes of differentiation. Although to all external appearance the animals are widely different, they have at least two characters, namely, the mantle and the foot, which are common to all molluscs.

The Clam

If living clams are available, observe the opening and closing of the shell and the method of locomotion.

Secure a preserved specimen. Slip your scalpel between the shells on the side opposite the hinges, keeping it against one of the shells, and gradually work it toward the hinge. If properly done, the large muscles will be severed and then the shell can be opened. Examine the clam "on the half shell." The flap of tissue attached to the shell, but which may have been loosened in opening, is the mantle. The two lamellae on each side of the body are gills. Do they resemble in any way the gills of a crayfish? Do they serve the same purpose? Remove those on the upper side, observing how they are attached to the body. With a razor knife or sharp scalpel cut the body parallel to the shell through the middle.

Fold back the cut part or remove it entirely. If well done, most of the internal organs should be visible. Observe the position of the cut muscles. What is their purpose? How is the clam shell opened? If your section is fairly median, the stomach should be found easily. It is surrounded by a digestive gland. Find the tube (esophagus) leading to the mouth. Find the intestine and trace it to the anus. The intestine passes through the pericardium, a bag-like structure which surrounds the heart and also through the ventricle of the heart. The solid part anterior and ventral to the viscera is the foot.

* *Make an outline drawing of the shell. Insert the anterior*
* * *adductor muscle, the posterior adductor muscle, and an outline of the digestive system. Include in your sketch a drawing of the foot.*

Just anterior to the posterior muscle, observe a tube folded upon itself. This is a kidney. Are there two kidneys? If so, where do they empty?

* *Sketch a kidney into your drawing.*
* *

Find the heart and trace any blood vessels that you can see. What do you think is the direction of the flow of blood? How does this system compare with that of the crayfish?

* *Sketch into your drawing the circulatory system, indicating*
* * *the direction of the flow of blood by arrow marks.*

The nervous system is very different from that observed in any other group. Those who are able to do so should try to trace it out. For details, examine a chart or lantern slide.

EXERCISE 32

Mollusca

Representatives of the various classes of this phylum are now to be examined. The student should understand how the name of each class is descriptive of the characters of the class.

The Squid

Class CEPHALOPODA

Examine a preserved specimen, noting the body regions into which the animal may be divided. Observe the tentacles, their number and any differences in structure. What would you think their function to be? These represent a highly modified foot. Examine the demonstration for the shell and for the mantle and mantle cavity. Study the eye. In what way does it differ from the eye of an insect? Other structures may be studied either by charts or lantern slides.

The Slug

Class GASTROPODA

Examine a preserved specimen, observing that the animal can not easily be differentiated into body regions. On the ventral side is the foot. At the anterior end on the dorsal side is a shield-shaped structure. This is the mantle. The large opening in the side of the mantle is the pneumostoma, a breathing pore, which opens into a tube extending down into the mantle cavity. This latter serves as a respiratory organ somewhat in the manner that a lung does. The mouth is tri-radiate. The slit formed between the head and the foot should not be mistaken for the mouth. The eyes may not be extended but the cone-shaped tentacles on which they occur will be easily seen. There is another pair of tentacles—but they are probably completely retracted. Near the head, just below the anterior end of the mantle on the right side is the genital opening.

If living specimens are available, observe them, noting how they move, retract their tentacles and withdraw their eyes.

Examine the demonstration for the shell.

The Snail

Class GASTROPODA

Because of its distortion and the development of the spiral shell the snail is not a satisfactory animal for dissection by the beginner. Examine some of the specimens, finding as many structures as possible, then study the charts or lantern slides for the details which are necessary to complete the chart on page 68.

The Chiton

Class AMPHINEURA

Examine a specimen and find the foot. The mouth opens anterior to the foot, the anus posteriorly. Observe the number and arrangement of the bony plates on the dorsal surface.

A part of the mantle extends beyond the shell. Examine the demonstration for the mantle folds which secrete the plates. The gills, which you may be unable to see, lie along the sides between the mantle and the body wall.

With the information obtained fill out the table on page 68 and transfer it to your note book.

Some Characteristic Molluscs

Animals	Class	Head*	Foot*	Shell*	Habitat	Type of Symmetry	Method of Locomotion
Chiton							
Clam							
Slug							
Snail							
Squid							

* P = present, A = absent.

EXERCISE 33

A. Rotifera

There are a number of animals which are not easily classified into any of the established phyla. These are designated as animals of uncertain relationship. Also, there are some phyla which do not appear to be closely related to other phyla. Among these latter is the Phylum Rotifera. Hay infusion cultures often contain rotifers in abundance.

Secure a drop of culture and look for rotifers, which seem to be propelled by two "wheels" that, in motion, look like aeroplane propellers. A "tail," usually forked, is generally present. By attaching the tail the rotifer may move about in a circle. Sometimes it moves along by looping like a "measuring worm." Find as many different kinds of rotifers as possible and observe differences among them. Find a specimen at rest and watch the gastric mill work. Look also for eggs. These usually are large and are therefore quite evident.

For details of anatomy, examine chart or lantern slide.

B. Invertebrate Larval Forms

The idea that the individual repeats, in a somewhat abbreviated manner to be sure, the general route over which the group traveled in its evolutionary origin, has led many zoölogists to seek the "key" forms which appeared in this process. In the invertebrates, much importance is attached to the larval forms. Species having similar larva are thought of as being more closely related than those with different larval forms. Several larval types have come to be well recognized.

Trochophore

Examine the demonstration of this type of larva. Consult the chart or lantern slide for the names of the organs.

* *Draw and label, including the mouth, stomach, anus, ciliated*
* * *mesoblastic band; and if possible, the "brain" and nephridion.*

Various stages of development are to be found on the slides. Check them over. Compare this larva with the rotifer which you have observed previously.

* *Sketch.*
* *

Since this type of larva is typical of many rotifers, molluscs, worms, and certain chordates such types of animals have been believed by some zoölogists to be related, but recent studies have thrown doubt on such criteria. Similarity in larval forms may be brought about by similarities in habitats and habits. The trochophore may be only an adjustment to a pelagic mode of life.

Pilidium

Examine the lantern slide illustrating this type of larva.

* *Sketch.*

* *

Tornaria

This larva apparently does not occur in non-chordates, but does resemble the larva of the echinoderms (See Hegner, 347).

* *Sketch.*

* *

Bipinnaria

Examine slide. If detail is not evident, see lantern slide or chart. Compare with tornaria.

* *Sketch.*

* *

Veliger

The larvae of certain molluscs are called veliger. In their early development they are quite similar to the trochophore larva of some annelids. The changes in metamorphosis indicate retrogressive transformation.

For details of structure, see chart or lantern slide.

* *Sketch.*

* *

EXERCISE 34

For this exercise the student will be given a "key" which is to be used in classifying invertebrates. The instructor will demonstrate the use of the key, after which the student is expected to work independently.

The number of specimens to be classified will be determined by the time available and the difficulty involved in the individual specimen.

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